Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	871	thorl.xp.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 13:29
L2	57	l1 and (heat or thermal) adj processor	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 13:29
L3	57	l1 and ((heat or thermal) adj processor)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 13:42
L4	2	tran-huan.xp. and ((heat or thermal) adj processor)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 13:32
L5	5	("5580478" | "5990461" | "6007971" | "6288370" | "6297476").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2005/11/16 13:40
L6	497	l1 and ((heat or thermal) adj (process$4 or develop$5))	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 13:43
L7	28	tran-huan.xp. and ((heat or thermal) adj (process$4 or develop$5))	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 13:43
L8	87970	(liquid adj2 (discharg$4 or inject$4))	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 13:49
L9	528	l8 and (coil$1 near5 $6magnetic)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 14:42
L10	86	l9 and (moving near10 coil)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 14:44

L11	5	l10 and (vertical$4 near4 $6magnetic)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 14:43
L15	13	("4520375" | "5501893" | "5668579" | "5754205" | "5783340" | "5798283" | "5804084" | "5821951" | "5828394" | "5919548" | "5963788" | "6082208" | "6127198").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2005/11/16 14:41
L16	4110	(b41j002/04 or b41j002/06).ipc.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 14:42
L17	75	l16 and (coil$1 near5 $6magnetic)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 14:42
L18	1	l17 and (vertical$4 near4 $6magnetic)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 14:43
L19	18	l17 and (moving near10 coil)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 14:44
S1	2	"6350015".pn.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 09:15
S2	0	wo-199903680-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 09:15
S3	2	wo-9903680-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 09:15
S4	2	ep-888888-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 09:15

S5	2	ep-887185-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 09:16
S6	2	jp-2001270104-$.did.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 09:20
S7	87970	(liquid adj2 (discharg$4 or inject$4))	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:15
S8	528	S7 and (coil near5 $6magnetic)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:17
S9	58	S8 and (liquid adj chamber)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:24
S10	65	nakao-isamu.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:24
S11	3	S10 and liquid	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:25
S12	50	ishimoto-tsutomu.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:25
S13	3	S12 and liquid	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:25
S14	125	uryu-masaru.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:25

S15	27	S14 and liquid	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:26
S16	214	ohashi-yoshio.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:26
S17	14	S16 and liquid	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:27
S18	244	kondo-takao.in.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:27
S19	26	kondo-takao.in. and liquid	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:28
S20	13	furuki-motohiro.in. and liquid	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 11:31
S21	44	yamamoto-masanobu.in. and liquid	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2005/11/16 13:28

DERWENT-ACC-NO: 2002-284530

DERWENT-WEEK: 200233

TITLE: Ink droplet ejection device for printer, facsimile, has nozzle drive circuit with permanent magnet arranged between electromagnetic coil and back plate

PATENT-ASSIGNEE: VICTOR CO OF JAPAN[VICO]

PRIORITY-DATA: 2000JP-0085248 (March 24, 2000)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
JP 2001270104 A	October 2, 2001	N/A	012	B41J 002/045

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
JP2001270104A	N/A	2000JP-0085248	March 24, 2000

INT-CL (IPC): B41J002/045, B41J002/055

ABSTRACTED-PUB-NO: JP2001270104A

BASIC-ABSTRACT:

NOVELTY - A flexible and permeable nozzle plate (2) which has a nozzle (20) for ejecting ink droplets, is vibrated by electromagnetic force. A nozzle drive circuit (4) having a permanent magnet (41) arranged between an electromagnetic coil (40) and a back plate (42), drives the nozzle for ejecting ink.

USE - For printer, facsimile.

ADVANTAGE - Increases design freedom and improves productivity.

DESCRIPTION OF DRAWING(S) - The figure shows an enlarged sectional view of principal part of ink droplet ejection device. (Drawing includes non-English language text).

Nozzle plate 2

Nozzle drive circuit 4

Nozzle 20

Electromagnetic coil 40

Permanent magnet 41

Back plate 42

CHOSEN-DRAWING: Dwg.1/11

DERWENT-CLASS: P75 T04 W02

EPI-CODES: T04-G02: W02-J:

Document Identifier - DID (1):

JP 2001270104 A

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates to the drop injection device which builds airline printers, such as a printer and facsimile, about a drop injection device. Especially this invention forms a drop from a liquid, and relates to the drop injection device made to inject this drop from a nozzle.
[0002]
[Description of the Prior Art] The typical ink jet method adopted as the drop injection device which builds airline printers, such as a printer and facsimile, is equipped with the nozzle which makes the minute drop of ink inject, and the actuator for making ink inject from this nozzle. The heater element which is made to carry out ebullition expansion of a piezo ceramic or the ink solvent, and acquires the injection force as this actuator is used. The former is called a piezo method and the latter is called the bubble jet (trademark) method. The common feature of these methods is generating the minute ink droplet by reducing the ink chamber volume with an actuator, heightening a pressure, and injecting ink from a minute nozzle in an instant.
[0003] However, in order to heighten the pressure in an ink chamber, to make ink inject from a nozzle and to suppress the recess of the pressure to an ink supply way, this kind of method made the ink supply way crooked long further thinly, and has set up the flow resistance of ink highly. For this reason, it is necessary to make the fluidity of ink high so that ink can be supplied with the negative pressure after injection of the ink from a nozzle, and in an ink chamber. However, it is difficult to realize the drop injection device made to inject pigment ink with high viscosity, oily ink, etc. at a high rate.
[0004] Then, in the drop injection device, the water color ink of a high fluidity is used abundantly. However, use of water color ink produces the following various troubles. The water resisting property and weatherability of water color ink run short, and a blot of water color ink, feathering, rear-face extraction, etc. occur [1st] in a regular paper. The ink supply way which was made crooked thin further for a long time as mentioned above, and set [2nd] up the flow resistance of ink highly with the minute bubble which exists in water color ink even if it uses viscous low water color ink will lose the function. It is very difficult to restore, once it gets an ink supply way blocked in the 3rd. To the 4th, the ink supply way and the ink chamber are expensive with complicated structure. And a nozzle, the ink chamber, the piezo ceramic or the heater element, and the crooked thin long ink supply way (closed conduit) consisted of [5th] structures in which the multilayer became complicated, and since it was the complicated structure of requiring ultra-precision machining, implementation of the drop injection device which has multiple-string nozzle structure was difficult at the long picture, and it was difficult [it] to realize a cheap high-speed printing printer.
[0005] The liquid regurgitation equipment (LIQUID PROJECTION APPARATUS) which can solve the above-mentioned technical technical problem is indicated by the international public presentation number WO 99/No. 55140 official report. This liquid regurgitation equipment fixes a piezo ceramic to a nozzle plate, without pressurizing a liquid by making a nozzle plate crooked with this piezo ceramic, is equipped with the description of making a drop inject from nozzle opening, and can imagine it to be what can inject in the formation list of a drop by the velocity head (dynamic pressure) produced from such a description into a liquid.
[0006] The Bernoulli's theorem generally expressed with a degree type <1> in the flow tube which consists of a fixed number of elementary streams is realized.
[0007]
P+rho v2 /2+rhogh= regularity -- <1> p:fluid-pressure rho:fluid-density v:fluid rate g: The fluid pressure p produced from a gravitational acceleration h:flow tube height quiescent state into the liquid on the nozzle plate driven by rate vm/sec is equivalent to the velocity head (rate fall) of the 2nd term of the above-mentioned formula <1>, and this fluid pressure p is impressed to the oil level of a nozzle. Therefore, in the above-mentioned liquid regurgitation equipment, the ink inhalation process into internal pressure impression of the ink chamber for injection of a liquid ink drop, the suppression structure (for example, ink supply way which was made crooked long further thinly and raised flow resistance) of the pressure omission from an ink supply way, and the ink chamber after the drop regurgitation etc. becomes unnecessary.
[0008]

[Problem(s) to be Solved by the Invention] That a high rate and the drop injection device which enabled efficient and drop injection of high density, and was further excellent in dependability at the productivity list should be developed in view of invention indicated by the above-mentioned international public presentation official report, although this artificer was not a well-known technique, he carried out the following fundamental researches. That is, the nozzle plate which coated the stainless plate with the polyimide sheet, or the nozzle plate of a polyimide sheet was prepared, the bimorph or the monomorph of a piezo ceramic was used as a transducer, the drive frequency of the resonance frequency near 100kHz was given to the nozzle plate with the control frequency of 4kHz - 10kHz, the vibrational state of a nozzle plate was measured, and the consideration was performed.

[0009] (1) -- an oscillating cycle although the amplitude of a nozzle plate will become a high scale factor if it excites with resonance frequency, until it reaches the large amplitude -- **** -- in improvement in the speed, a limit arises from things. In a fundamental research here, the single figure - about double figures delta frequency of the drive frequency of a transducer and control frequency which used the piezo ceramic is made different. In order to perform drop injection across the drop injection limitation and to earn the count of vibration of a transducer by enlarging the amplitude vibrated in near the resonance frequency of a transducer, or in order to secure the time amount in which vibration is settled, it is thought that low control frequency is required. Resonance frequency becomes high because moving part has the high rigidity structure which the piezo ceramic hard thick moreover pasted up firmly.

[0010] (2) In the drop injection device which has multiple-string nozzle (multi-nozzle) structure, big dispersion occurs for resonance frequency, a resonance scale factor, etc. according to each minute error, such as a transducer, a nozzle plate, a dimension of jointing, and mass. Dispersion, such as such resonance frequency, cannot cause spots of printing, and cannot obtain the printout of high quality. Furthermore, dispersion between the drop injection devices in mass production method also becomes large, and spots occur in a printout for every drop injection device.

[0011] (3) Moreover, although drop injection efficiency will go up if drive frequency approaches the drop generation period and meniscus resonance frequency by the diameter of a nozzle, liquid viscosity, and surface energy, this drop injection efficiency also causes dispersion between nozzles and between drop injection devices.

[0012] (4) Further, with the property of a liquid, drive frequency cannot receive a limit and cannot carry out business of the too high resonance frequency, either. The rate of the nozzle plate which generates the dynamic pressure of a liquid to the output of an actuator (a transducer and assembly of a nozzle plate) becomes small with increase of resonance frequency. Therefore, it is disadvantageous for improvement in the speed to make it excite with the high frequency beyond the need.

[0013] (5) Since rigidity is very high, the adapter of a piezo ceramic and a nozzle plate has resonance frequency with high 100kHz level. If rigidity increases and resonance frequency goes up a single figure as shown in drawing 11 , a rate will fall a single figure on the frequency below the resonance point. Two or more data into which drawing 11 changed load-rate k into, and resonance frequency was changed are shown. Even if resonance frequency changes, a resonance peak does not change. The rise of a resonance scale-factor ratio is compensating the fall of a fundamental rate (when it is the resonance scale factor 1). although a resonance crest is highly sharp when a resonance scale factor is high -- this logarithm -- it is shown that the sharpness on a shaft and straitness increase generating of dispersion in the injection property by dispersion in the resonance frequency of each nozzle.

[0014] (6) It is also possible to change the mass of the moving part of an actuator and to change resonance frequency. However, since a resonance scale factor will become high if mass is increased and resonance frequency is lowered, and a rate scale factor will become low if mass is decreased and resonance frequency is raised, it is inapplicable to the actuator which carried out the output design required from the first.

[0015] (7) In the fundamental research which this invention person performed, resonance frequency was lowered to about 100kHz (resonance frequency is still quite high), and in order to raise the amplitude, the prototype of the nozzle plate of the long and slender shape of a beam with a die length [of 9mm] and a width of face of 1mm was tried. If this nozzle plate is used and the drop injection device of 12 dots/mm multiple-string nozzle structure is made as an experiment, the die length (9mmx12) of the whole nozzle plate will amount also to 108mm. Now, it is inapplicable to a cheap general-purpose printer at all. Although the device of a miniaturization of liquid regurgitation equipment is also indicated by the above-mentioned international public presentation official report, it does not become the means which all of these contents of an indication can improve to a practical level.

[0016] Thus, in the velocity head (dynamic pressure) mold liquid injection device which makes a piezo ceramic a transducer, practical various technical problems were held and utilization was very difficult.

[0017] This invention is made in order to solve the above-mentioned technical problem. Therefore, the purpose of this invention is offering the drop injection device equipped with the actuator which has a design degree of freedom, and was excellent in productivity, and was excellent in dependability.

[0018]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the description of this invention is having considered as the drop injection device equipped with the nozzle plate which has the nozzle which makes a drop inject

and has flexibility and permeability, and the nozzle driving means which vibrates a nozzle plate according to electromagnetic force, and makes a drop inject from a nozzle at least.
[0019] Here, it was used in the semantics of the property in which it can bend in the direction of board thickness which needs "flexibility" in order to make a drop inject at least, and a nozzle plate is equipped with the function as a diaphragm required for injection of a drop while it is equipped with a nozzle. With "permeability", in order make a drop inject and to sag a nozzle plate according to electromagnetic force (or it is made to vibrate), it is used in the semantics of the property attracted or repelled with an electromagnet. Therefore, as for a nozzle plate, it is desirable to constitute a ferromagnetic metal plate as a subject at least. furthermore, the electromagnetism which a "nozzle driving means" is arranged between the permanent magnet countered and arranged in the nozzle plate, and a nozzle plate and a permanent magnet, and controls electromagnetic force -- a coil and electromagnetism -- it is desirable to equip a coil with the current feed zone which supplies a current, and the control section which controls supply of a current at least, and to be built. namely, the electromagnetism to which the drop injection device concerning this invention makes a nozzle plate moving part -- it has the mold actuator. A large rate can be obtained to fixed input energy, so that the mass of the nozzle plate as moving part, a spring constant, etc. are small.
[0020] In the drop injection device concerning this invention, by having equipped the nozzle plate with permeability at the flexible list, the nozzle plate itself can be made into the moving part for making a drop inject, and lightweight-ization of the nozzle plate itself can be realized further. Therefore, it can perform easily setting up resonance frequency and a resonance scale factor low, and the actuator which can avoid the unstable resonance point and can be made to generate a high rate near the resonance point in the optimal drive frequency corresponding to drop formation critical speed can be realized.
Furthermore, in the actuator which has the resonance point in a low frequency, since the time amount which maintains a drop regurgitation possible rate is securable for a long time (velocity amplitude is enlarged), 1 time of liquid discharge quantity is controllable by controlling this rate maintenance time amount the optimal. namely, electromagnetism with a high design degree of freedom -- the drop injection device equipped with the mold actuator is realizable.
[0021] It becomes unnecessary furthermore, to prepare the powerful glue line which bears mighty repeat shearing stress and tensile stress by having made the nozzle plate itself into moving part between piezo ceramics and nozzle plates which were explained in the conventional example. Therefore, it excels in productivity and the drop injection device equipped with the reliable actuator can be realized.
[0022]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing.
[0023] As shown in [structure of drop injection device] drawing 1 , and drawing 2 , the drop injection device 1 concerning the gestalt of operation of this invention vibrates the nozzle plate 2 which has the nozzle 20 which makes a drop 60 inject, and has flexibility and permeability, and a nozzle plate 2 by magnetism, is equipped with the nozzle drive 4 made to inject a drop at least, and consists of nozzles. The nozzle drive 4 corresponds to one example of the "nozzle driving means" concerning this invention. the nozzle device 4 -- a nozzle plate 2 -- countering -- alienation -- with the arranged permanent magnet 41 Make the spacer layer 3 intervene between a nozzle plate 2 and a permanent magnet 41, and it is arranged in it. and the electromagnetism which controls the magnetism of a permanent magnet 41 by doubling the nozzle 20 and center position which were formed in the nozzle plate 2, and arranging coil 40B -- with the coil object 40 electromagnetism -- the current feed zone 43 which supplies a current to coil 40B of the coil object 40, and electromagnetism -- it has at least the control section 44 which controls supply of the current to coil 40B of the coil object 40, and is constituted.
[0024] In the gestalt of operation of this invention, a high permeability metal and the plate-like part material specifically formed by the permalloy, Sendust, amorphous high permeability materials, etc. can be used for a nozzle plate 2 practical. the external surface (the inside of drawing 1 and drawing 2 , bottom front face) of a nozzle plate 2 -- a liquid -- **** -- although coating of the thin films, such as fluoridation silicon film, is carried out like and a liquid 6 can form a meniscus in a nozzle 20, extraction diffusion of the liquid is not carried out on the external surface of a nozzle plate 2
[0025] The nozzle 20 is constituted from a through tube regularly arranged in the predetermined pitch by the predetermined part of a nozzle plate 2. Here, in the case of the printer of the high quality of for example, 600dpi, a "predetermined part" means that a nozzle 20 is arranged in the location corresponding to 1 dot of pixels. A "predetermined pitch" is the semantics of spacing which can arrange the nozzle 20 of 600dots(es) in 1 square inch meter. The diameter of a nozzle 20 is preferably set up by about 1.7 times the minimum drop spherical diameter.
[0026] The permanent magnet 41 consists of monotonous configurations to which the bottom is made into the south pole among drawing 1 and drawing 2 , and it makes the bottom N pole, and through tube 41A which becomes two or more liquid supply paths in the location corresponding to a nozzle 20 is arranged by this permanent magnet 41. a permanent magnet 41 -- a nozzle plate 2 inside top -- the spacer layer 3 and electromagnetism -- each of the coil object 40 is intervened and arranged. On the permanent magnet 41, the back plate 42 is arranged further.
[0027] As shown in drawing 3 , the spacer layer 3 is formed using resin ingredients, such as non-magnetic metal ingredients, such as a tabular non-magnetic material, for example, aluminum, copper, or those alloys, or polyacetal, a polycarbonate, a polyamide, and polyimide. Much round shape hole 3A is arranged in the field corresponding to a nozzle 20 by this spacer layer

3. electromagnetism -- the coil object 40 consists of gestalten which consist of tabular gestalten which embedded much coil 40B which has through tube 40A in the center in the predetermined pitch, or printed much coil 40B in the predetermined pitch on the printed-circuit board. The back plate 42 shown in drawing 1 and drawing 2 is formed with the high permeability metal like the nozzle plate 2, and is formed by board thickness with a nozzle plate 2 thicker than a nozzle plate 2 in order to differ and to have hard nature. Through tube 42A is arranged in the field corresponding to a nozzle 20 by the back plate 42.
[0028] circular hole 3A of the spacer layer 3, and electromagnetism -- through tube 40A of the coil object 40, through tube 41A of a permanent magnet 41, and through tube 42A of a back plate 42 -- respectively -- ** -- the center position of a nozzle 20 is made in agreement Each of these circular hole 3A, through tubes 40A and 41A, and through tube 42A forms a liquid supply path. the spacer layer 3 is circular -- the bore of hole 3A, and electromagnetism -- the outer diameter of coil 40B of the coil object 40 is set up equally, and is generating space 3B which can sag the nozzle plate 2 stuck on the spacer layer 3.
[0029] The chamber case 7 is arranged in the periphery on a back plate 42, and it fills up with the liquids 6, such as ink, in the building envelope of this chamber case 7. This liquid 6 is supplied to a nozzle 20 through the liquid supply path formed by above-mentioned circular hole 3A, through tubes 40A and 41A, and through tube 42A. Sign 6S are the oil level of a liquid 6. The chamber case 7 is formed with metallic materials, such as stainless steel, and this chamber case 7 is attached in the back plate 42 by attachment means, such as welding.
[0030] Here, a liquid 6 can express with a degree type <2> the marginal fall h leaked from a nozzle 20.
[0031] h=2 sigma/rrhog -- <2>sigma -- :liquid surface tension r:nozzle radius rho:fluid density g: -- when using a silicone oil (the liquid surface tension sigma is 0.02 N/m, and fluid density rho is 1000 kg/m3) for gravitational acceleration 6, for example, a liquid, and setting the nozzle radius r to 15 micrometers, the marginal fall h is set to about 270mm from the above-mentioned formula <2>, and there are sufficient allowances to oil-level 6S [about 10mm].
[0032] electromagnetism -- in the bore of through tube 40A of the coil object 40, when referred to as 0.5mm, the marginal fall h of the liquid 6 held with the bore of this through tube 40 is slight -- a liquid 6 can be made to flow in space 3B formed from the spacer layer 32 by gravity, since it is 8 micrometers even if each part material which builds a liquid supply path is liquid repellance
[0033] Thus, the interior of space 3B which flows by self-weight does not accumulate a pressure, and a liquid 6 is unnecessary for welding pressure or suction pressure to supply of a liquid 6. That is, the drop injection device 1 concerning the gestalt of operation of this invention is using the open sand mold chamber to the semi-closed-forging-die chamber of the conventional pressurization mold ink jet method. Furthermore, since a liquid 6 flows down by self-weight, even if the bubble is contained in the liquid 6, this bubble can be extracted automatically.
[0034] the electromagnetism in which the drop injection device 1 concerning the gestalt of operation of this invention has the spacer layer 3 and two or more coil 40B so that I may be understood in the [assembly of drop injection device] above-mentioned explanation -- it can assemble easily by carrying out the laminating of each plate-like part material of the coil object 40, a permanent magnet 41, and a back plate 42, and attaching the nozzle plate 2 which is plate-like part material still like the spacer layer 3. That is, the drop injection device 1 is formed by the actuator which carried out the laminating of two or more plate-like part material.
[0035] Furthermore, in the drop injection device 1, since each of a back plate 42 and a nozzle plate 2 adsorbs with the suction force of a permanent magnet 41, an assembly can be performed easily. electromagnetism -- since it is formed with non-magnetic material, a permanent magnet 41 is not adsorbed, but since the substrate and the spacer layer 3 of the coil object 40 are suppressed by the adsorption power of a nozzle plate 2, they can perform mutual immobilization by adhesion easily.
[0036] furthermore, electromagnetism -- the suction force of a permanent magnet 41 is made larger than the electromagnetic force generated in coil 40B of the coil object 40, and with the suction force of this permanent magnet 41, it sets up so that it may work in the direction which always attracts a nozzle plate 2 -- having -- **** -- electromagnetism -- the force of exfoliating adhesion between the coil object 40 and the spacer layer 3 -- there is nothing -- electromagnetism -- the adhesion life between the coil object 40 and the spacer layer 3 is eternal.
[0037] On a back plate 42, the drop injection device 1 can be completed by the chamber case 7 being joined at the end.
[0038] [Actuation of a drop injection device], next actuation of the drop injection device 1 concerning the gestalt of operation of above-mentioned this invention are explained.
[0039] Line-of-magnetic-force 41M generated with the permanent magnet 41 of the drop injection device 1 draw the loop formation which arrives at the both sides of a nozzle plate 2 and a back plate 42, as shown in drawing 1 . here -- from a nozzle 20 side -- seeing -- the current i of the direction of a clockwise rotation -- electromagnetism -- if it passes to coil 40B of the coil object 40, coil 40B can be made to generate line-of-magnetic-force 40M as shown in this drawing 1 In this case, since a direction becomes the reverse sense, line-of-magnetic-force 41M generated with the permanent magnet 41 and line-of-magnetic-force 40M which were generated by coil 40B negate both magnetic flux mutually. The suction force of the nozzle plate 2 by the magnetic flux phi 2 generated by the magnetic flux phi 1 and coil object 40B which are generated with a permanent magnet 41 is proportional as shown in a degree type <3>.
[0040] phi2=(phi1+phi2) 2 -- <3> Here, the magnetic flux phi 1 generated with a permanent magnet 41 is farther [than the

magnetic flux phi 2 generated by coil 40B] large, and since it can ignore as phi22**0, the above-mentioned formula <3> can be rewritten like a degree type <4>.

[0041] phi2=phi – 12+2phi1phi2 – the magnetomotive force of the generating-by <4> coil 40B magnetic flux phi 2 – the coil current i and several coiling – since it is proportional to the product of N, the square of magnetic flux phi is controllable by the coil current i to be expressed to a degree type <5>.

[0042]

phi2=phi12+2phi1 iN/Rm – <5> Rm: When the magnetic-circuit resistance to coil magnetic flux, therefore the coil current i are 0 (i= 0), as a sign 21 is attached to drawing 1 and an alternate long and short dash line shows, a nozzle plate 2 is attracted by the magnetic flux phi 1 (line-of-magnetic-force 41M) to which a permanent magnet 41 is not changed, and is in the condition of having been sagged inside space 3B. As the suction force of a nozzle plate 2 decreases, a sign 22 is attached to drawing 1 at the time of the magnetic flux phi 1 which the magnetic flux phi 2 by the coil current i of coil object 40B generates with a permanent magnet 41, and hard flow and a broken line shows, bending of a nozzle plate 2 is in the condition of having decreased.

[0043] It becomes large more nearly further than the alternate long and short dash line which magnetic flux phi 12 will increase if the coil current i is passed to coil 40B so that it may become in the same direction as the magnetic flux phi 1 which the magnetic flux phi 2 generated by coil 40B although not illustrated generates with a permanent magnet 41, and shows bending of a nozzle plate 2 with a sign 21 toward the interior of space 3B.

[0044] As explained above, in the drop injection device 1, by controlling the magnitude and the direction of the coil current i which are passed to coil 40B, the magnetism (suction force) impressed to a nozzle plate 2 can be controlled, and bending of a nozzle plate 2 can be controlled.

[0045] Although the efficiency as an actuator of the drop injection device 1 can be raised since line-of-magnetic-force 40M generated by line-of-magnetic-force 41M and coil 40B generated with a permanent magnet 41 pass the low spacer layer 3 of magnetic reluctance when the spacer layer 3 is used as a permeability object, a high-frequency property will fall according to increase of an inductance conversely. Therefore, as for the spacer layer 3, in this point, considering as non-magnetic material is desirable.

[0046] In the drop injection device 1 concerning the gestalt of operation of [modification of nozzle plate] this invention, since the moving part as an actuator is considering as the nozzle plate 2 which has flexibility, this nozzle plate 2 is thin, tends to bend, and can also form mass small. The field of a nozzle plate 2, especially a nozzle 20 can make it easy to bend extraordinarily by setting nozzle plate 2 and arranging many slits 23 in the circular movable side around a nozzle 20, as shown in drawing 4 . He can understand this in a formula of bending of the disk of circumference immobilization, and bending of a both-ends fixed beam as known well. By setting the width method of a slit 23 as about [of the inside diameter of a nozzle 20 / 1/several], the liquid exsorption fall h from a slit 23 increases several times, and when injecting a drop from a nozzle 20, the outflow of the liquid 6 from a slit 23 can be prevented so that he can understand from the above-mentioned formula <2>. In addition, the inside diameter of a nozzle 20 can use 30 micrometers practical, for example. In the manufacture process of a nozzle plate 2, the same thing as a nozzle 20 of a slit 23 which it depends etching process 2 or is manufactured by the same mechanical punching process is desirable, when raising productivity.

[0047] Since mass does not change when making it easy to bend a nozzle plate 2 so that clearly from above-mentioned drawing 11 explained with the conventional technique of the [drop injection principle] point, resonance frequency omega 0 falls and the velocity amplitude near the resonance frequency omega 0 increases. as shown in drawing 1 , a nozzle plate 2 drives in the direction of said drawing 2 Nakaya mark A – having (bending being produced) – the liquid 6 which touches the field which bending of this nozzle plate 2 produced also bends, the liquid 6 of a part and this volume drives (flow), and a drop 60 is injected from a nozzle 20. Since the same rate as rate vm/s of a nozzle plate 2 can be obtained in the meniscus of a nozzle 20, if change of flow tube height h of the above-mentioned formula <1> is disregarded, it can ask for dynamic pressure p like a degree type <6>.

[0048] P=rho v2/2 – As the dynamic pressure p expressed with the <6> above-mentioned types <6> shows to drawing 5 (B) and drawing 5 (C), the meniscus of a nozzle 20 resists surface energy, swells, and generates 6'. It will swell, if the rate v of a nozzle plate 2 is reduced when [this / at which it projected] it swells and 6' becomes predetermined height, supply of the liquid 6 to 6' stops, and since it has inertial force, it is cut with that inertial force, and swelling 6' becomes a drop 60 and is injected. The rate of flow of the fluid 6 which passes a nozzle 20 is shown in drawing 5 (A).

[0049] The numeric data of two real examples of a nozzle plate 2 is shown in drawing 6 (A). In this drawing 6 (A), it is the nozzle plate 2 which arranged the slit 23 indicated to be "those with a slit" of a nozzle plate format to above-mentioned drawing 4 , and is the nozzle plate 2 which is not arranging the slit 23, saying "he has no slit."

[0050] When a slit 23 is arranged in a nozzle plate 2, the rigidity of a nozzle plate 2 falls, and both the resonance point rate v and the velocity pressure force pv become large, and can make small marginal injection driving force F of a pressure actuator required for drop formation with 2.79mN(s). Furthermore, in the nozzle plate 2 which arranged the slit 23, the resonance frequency resonance frequency omega 0 can be low set up with about 7.23kHz. Furthermore, in proportion to this thinness,

resonance frequency omega 0 can be lower set up by making thickness of a nozzle plate 2 thinner, for example. In the moving-part radius a of a nozzle plate 2 (refer to drawing 1 .), resonance frequency omega 0 can be lowered in inverse proportion to the square of this moving-part radius a. Thus, since it can perform easily lowering load-rate k and setting up low resonance frequency omega 0 and the resonance scale factor v, the actuator 1 which stops the unstable resonance point and generates a high rate near the resonance point in the optimal drive frequency corresponding to the formation critical speed of a drop 60, i.e., a drop injection device, is realizable. In addition, in the nozzle plate 2 which lowered rigidity as mentioned above, as shown in drawing 5 R> 5 (B) thru/or drawing 5 (D), by coating the sheets plastic 25, such as polyimide resin film, by lamination on the external surface, the attenuation coefficient as an actuator can be raised further and a resonance peak can be pressed down easily.

[0051] After bending of the nozzle plate 2 of the direction of arrow-head A shown in drawing 1 , drawing 5 (A), and drawing 5 (B) performs injection actuation of a drop 60, electromagnetism -- by generating the magnetic flux which negates line-of-magnetic-force 41M which passed the coil current i to coil 40B of the coil object 40, were made to generate line-of-magnetic-force 40M, and were generated with the permanent magnet 41 Since the liquid 60 with which bending of a nozzle plate 2 is quickly returned, and touches on the inside near the nozzle 20 of a nozzle plate 2 becomes negative pressure, the meniscus side of a nozzle 20 turns into a concave surface, as shown in drawing 5 (D). Since the concave surface of this meniscus side is storing the strain energy of the direction of arrow-head B, if a nozzle plate 2 is attracted as a sign 21 is attached to drawing 1 in the timing to which this meniscus side returns from a concave surface to a flat surface and an alternate long and short dash line shows, drop injection effectiveness can be gathered. Since the return to the direction of arrow-head B of a nozzle plate 2 is disconnection of the bending energy of a nozzle plate 2, the injection time amount of one drop of drop 60 becomes almost equal to one period of resonance frequency omega 0.

[0052] In the drop injection device 1 concerning the gestalt of operation of this invention explained beyond [the actuator multiple-string structure of a drop injection device], the case where actuator multiple-string structure is realized is explained.

[0053] it is shown in drawing 7 -- as -- the electromagnetism of the drop injection device 1 -- although the coil object 40 is not what is limited to this number of layers -- the electromagnetism of four layers -- the laminating of the coil layers 401-404 is carried out one by one, and it is built. such electromagnetism -- the coil layers 401-404 are constituted from a printed-circuit board by each. namely, electromagnetism -- the coil layer 401 is equipped with an insulating substrate 410, the input terminal 411 on an insulating substrate 410, the coil wiring 412 on an insulating substrate 410, the connection hole wiring (through hole wiring) 413 that leads to a rear face from the front face of an insulating substrate 410, and the output terminal 414 on the rear face of an insulating substrate 410, and is constituted. the same -- electromagnetism -- the coil layer 402 is equipped with an insulating substrate 420, the input terminal 421 on an insulating substrate 420, the coil wiring 422 on an insulating substrate 420, the connection hole wiring 423 that leads to a rear face from the front face of an insulating substrate 420, and the output terminal 424 on the rear face of an insulating substrate 420, and is constituted. electromagnetism -- the coil layer 403 is equipped with an insulating substrate 430, the input terminal 431 on an insulating substrate 430, the coil wiring 432 on an insulating substrate 430, the connection hole wiring 433 that leads to a rear face from the front face of an insulating substrate 430, and the output terminal 434 on the rear face of an insulating substrate 430, and is constituted. electromagnetism -- the coil layer 404 is equipped with an insulating substrate 440, the input terminal 441 on an insulating substrate 440, the coil wiring 442 on an insulating substrate 440, the connection hole wiring 443 that leads to a rear face from the front face of an insulating substrate 440, and the output terminal 444 on the rear face of an insulating substrate 440, and is constituted.

[0054] the electromagnetism of the maximum upper layer -- the output terminal 414 of the coil layer 401, and a top to the 2nd step of electromagnetism -- it connects mutually electrically between the input terminals 421 of the coil layer 402. the 2nd step of electromagnetism -- the output terminal 424 of the coil layer 402, and a top to the 3rd step of electromagnetism -- it connects mutually electrically between the input terminals 431 of the coil layer 403. and the 3rd step of electromagnetism -- the output terminal 434 of the coil layer 403, and the electromagnetism of the lowest layer -- it connects mutually electrically between the input terminals 441 of the coil layer 404. namely, the electromagnetism of an odd level eye -- the electromagnetism of a coil layer and an even level eye -- connection between coil layers is made outside -- having -- the electromagnetism of an even level eye -- the electromagnetism of a coil and an odd level eye -- connection between coil layers is made inside.

[0055] the electromagnetism of the maximum upper layer -- if the coil current i is supplied to the input terminal 411 of the coil layer 401 -- the coil wiring 412, 422, 432, and 442 of each class -- respectively -- being alike -- the coil current i flows counterclockwise. each thickness of insulating substrates 410, 420, 430, and 440 -- for example, several 10 micrometers -- setting up -- each thickness of the coil wiring 412, 422, 432, and 442 -- several 10 micrometers -- carrying out -- a circumference pattern -- carrying out -- such electromagnetism -- laminating the coil layers 401-404 -- the electromagnetism of a suitable impedance number of turns to carry out [several volts] a low-battery drive -- the coil object 40 can be manufactured.

[0056] it is shown in drawing 8 -- as -- electromagnetism -- the electromagnetism of the maximum upper layer of the coil object 40 -- to the input terminal 411 of the coil layer 401 each of the signal lines SL1-SL3 which extended in the line writing direction

and were arranged at intervals of predetermined in the direction of a train connects electrically -- having -- the electromagnetism of the lowest layer -- to the output terminal 444 of the coil layer 404 Each of the access lines AL1-AL3 which extended in the direction of a train and were arranged by the line writing direction at intervals of predetermined is connected electrically. the electromagnetism arranged two-dimensional by signal lines SL1-SL3 being alike, respectively, and arranging a drive transistor, and the access lines' AL1-AL3 being alike, respectively, and arranging a switching transistor although not illustrated -- the drop injection device 1 equipped with the actuator of two-dimensional array which can carry out random access of the coil layer is realizable. A short high pulse signal can be impressed to signal lines SL1-SL3, and one injection actuation can be made to perform to a nozzle plate 2 in such a drop injection device 1. Although it goes and comes back to a nozzle plate 2 one time to one pulse signal according to a mechanical time constant, the access rate to next step Rhine is accelerable by setting up a pulse signal short. Since the nozzle plate 2 of the first Rhine will just have returned to a non-signal location by the time access of Rhine of one period is completed, the same high-speed drive as an one-line head is realizable. For example, when printing 60 lines in 1 period tau n seconds, signal impression time amount per line can be shortened with taun / 60 seconds. In addition, this example is not multi-gradation printing but binary printing.

[0057] The numeric data of two real examples of the actuator of two-dimensional array is shown in drawing 6 (B). In this drawing 6 (B), it is the existence of the slit 23 of a nozzle plate 2 as drawing 6 (A) explained "those with a slit", and "he had no slit."

[0058] Although resonance frequency becomes as 7.23kHz and a period becomes comparatively long even when it has a slit 23 since the Rhine circumference time amount can be made equal to the resonant period of an actuator, high-speed printing is realizable. Even if it makes access timing of all Rhine late (rate from which 30 times and sufficient gradation are obtained.) as a resonance half period, printing time amount is 52 seconds and can perform remarkable high-speed printing.

[0059] The diagram and drawing 10 which carried out simulation of the output rate of the nozzle plate [as opposed to / drawing 9 / the input pulse signal width of face to the actuator of 0.5 in a damping coefficient zeta] 2 are the diagram which carried out simulation of the output rate of the nozzle plate [as opposed to the input pulse signal width of face to the actuator of 0.2 in a damping coefficient zeta] 2. electromagnetism -- impression of electromagnetic force with the coil object 40 is a step wave which starts by 0 and is maintained 12% 8% 2% to periodic tau[of resonance frequency omegan] n. v (t) is a velocity output to the step input to maintain. It can understand it that the magnitude of an output rate is proportional to a pulse duration, and exceeds a quadrant period to become small. However, the area of an output rate increases to 0.5 periods (in addition, if 0.5 periods are approached, change will become blunt.). The volume of the drop 60 which will be injected if an output rate reaches a predetermined value and extrusion of a drop 60 starts is equivalent to this area. Thus, the drop 60 of the desired volume can be injected by one movement of a nozzle plate 2. Thus, it is desirable to perform control of the volume of a drop 60 in the range of 1/about 4 period. The vibration after 1 period is mostly settled by setting this damping coefficient zeta to 0.5. Allowances to make Rhine access timing 0.5 periods, as described above are enough. Drawing 10 is the case where a damping coefficient zeta is set to 0.2. Although this damping coefficient zeta is larger than the case (damping coefficient zeta= 0.16) of the spring constant k= 0.1 of drawing 11 , it has left the big velocity amplitude to the 2nd cycle. In such the condition, injection control of a positive amount cannot be performed in a single cycle. The actuator which has 0.5 for the high damping coefficient zeta as shown in drawing 9 is useful. The frequency characteristics of this actuator are equivalent to the spring constant k= 0.01 of drawing 11 R> 1.

[0060] As explained above, spring constant k can be made low, resonance frequency omegan can be lowered, and a injection rate can be made high by supplying one injection pulse signal which raised the damping coefficient zeta and controlled pulse signal width of face, and controlling the magnitude of the drop 60 injected.

[0061] In the drop injection device 1 applied to the gestalt of operation of this invention as explained beyond [the effectiveness of a drop injection device] The nozzle plate 2 which has a nozzle 20 and has flexibility and permeability, Have the nozzle drive 4 and the inside of a nozzle plate 2 is made to carry out contact maintenance of the liquid 6. Since drive a nozzle plate 2 to an inside side (making it bend), the velocity pressure force is generated in a liquid 6, a liquid 6 is extruded from a nozzle 20 and it was made to make a drop 60 inject, the following effectiveness can be acquired.

[0062] (1) In the flexible large nozzle plate 2, the resonance point can be easily set as the optimal desirable frequency. Those balance can determine a desirable frequency by making a injection rate, a need injection pressure, min, and the maximum drop weight into the main parameters.

[0063] (2) Since low resonance frequency can be set as the drive of a nozzle plate 2, a big rate is obtained, and a drop injection pressure can also be enlarged and can improve injection effectiveness.

[0064] (3) Since a resonance scale factor can be set up low, the amplitude the resonance point and near the resonance point can be stabilized, and a multi-nozzle actuator can be realized easily.

[0065] (4) The nozzle plate 2 as moving part consists of single metallicity flexible plates without the electric wire for a drive, and since there is no jointing which repeated stress big moreover joins, dependability can attain reinforcement highly.

[0066] (5) Since the nozzle plate 2 as moving part is formed thinly and is lightweight-ized as a result in order to give flexibility, it can raise acceleration and velocity-output effectiveness.

[0067] (6) Since it is realizable by the wiring substrate and the multilayer printed circuit board with versatility high on a concrete target, a 2-dimensional arrangement actuator can improve productivity.
[0068] (7) Since the area which the flexible part (bending part) of a nozzle plate 2 occupies is not large, the actuator of an overly detailed two-dimensional array is realizable.
[0069] (8) Since between two or more nozzles 20 arranged in the nozzle plate 2 is classified in the spacer layer 3, the cross talk between nozzles 20 can be decreased.
[0070] (Gestalt of other operations) Although the gestalt of two or more above-mentioned implementation indicated this invention, if this invention is limited, he should not understand the statement and the drawing which make a part of this indication. The gestalt, example, and employment technique of various alternative implementation will become clear to this contractor from this indication.
[0071] for example, the drop injection device 1 concerning the gestalt of the above-mentioned implementation -- setting -- electromagnetism -- the electromagnetism of the coil object 40 -- although the number of layers of a coil layer was made into four layers -- this invention -- the electromagnetism of less than four layers or five layers or more -- a coil layer -- electromagnetism -- the coil object 40 may be built.
[0072] Thus, as for this invention, it is needless to say that the gestalt of various operations which have not been indicated here etc. is included. Therefore, the technical range of this invention is appointed only according to the invention specification matter concerning the above-mentioned appropriate claim.
[0073]
[Effect of the Invention] This invention can offer the drop injection device equipped with the actuator which has a design degree of freedom, and was excellent in productivity, and was excellent in dependability.

[Translation done.]